CHAPTER 6 - LANDSCAPE STRUCTURE, FLOWS, AND INTERACTIONS

Landscape Structure

The major elements of landscape structure are patches, corridors, and matrix.[1] Patches are defined as areas distinctly different in appearance from surroundings and may vary widely in size, shape, type, heterogeneity, and boundary characteristics. Corridors are narrow strips of land that differ from the matrix on either side, are usually attached to a patch of somewhat similar vegetation, but may also not be much different from the matrix. The matrix is the most extensive and most connected landscape element and plays the dominant role in controlling landscape dynamics.

Patch Types and Characteristics

Patches will be used to described different classes of vegetation as well as patches in the sense of vegetation classes that are distinctly different from the dominant vegetation within a landscape, i.e., a landscape structural element. Patch types will be different vegetation classes.

Types - For the Wolf Creek watershed there are several patch types: forested patches, wetland patches, rock/dry meadow patches, and altered patches. The forest patches are the different vegetation classes described in the vegetation section. Generally, the wetland and rock/dry meadow patches are smaller scale patches often imbedded within a larger forested type. Both of these patch types are unique or special habitats. The nonforest areas are lumped together and represent altered patch types. Included in the altered patches are rock quarries, facilities (Wolf Creek sort yard site), homes, dwellings, landscaped areas, and cleared pasture and agricultural lands. The altered patches and unique habitat patches are patterned after the Diaz and Apostol[2] approach of landscape design. The Patch Map (see Map 16) is the result of combining the vegetation maps with the unique habitats. It will be the basis for the landscape scale analysis.

Characteristics - There are several patch characteristics that are important to consider when characterizing landscapes. Some of these are patch size, patch numbers, patch shape, patch heterogeneity, and patch configuration. For the forest patches there are 9 separate forest patch types. The average patch size for the entire watershed has changed from 112 acres for all forested patches to 45 acres average patch size. This represents a reduction in patch size by almost 250 percent. Figure 20 illustrates the change in average patch size by forest vegetation class. The number of patches has increased the same amount, 250 percent over the past 25 years. The greatest increase in number of patches or fragmentation is in the clear cuts, mature over young, and old forest patch types. Figure 21 displays the change in numbers of patches by type within the watershed.

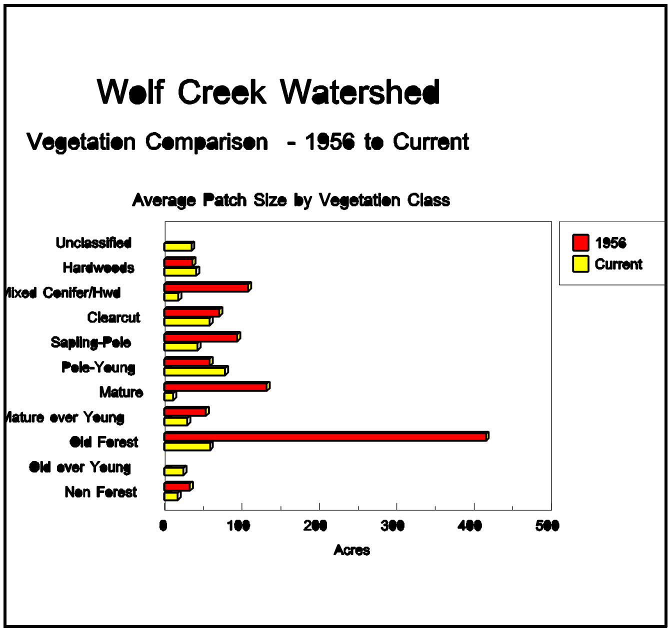

Figure 21: Changes in Average Patch Size From 1956 to the Present

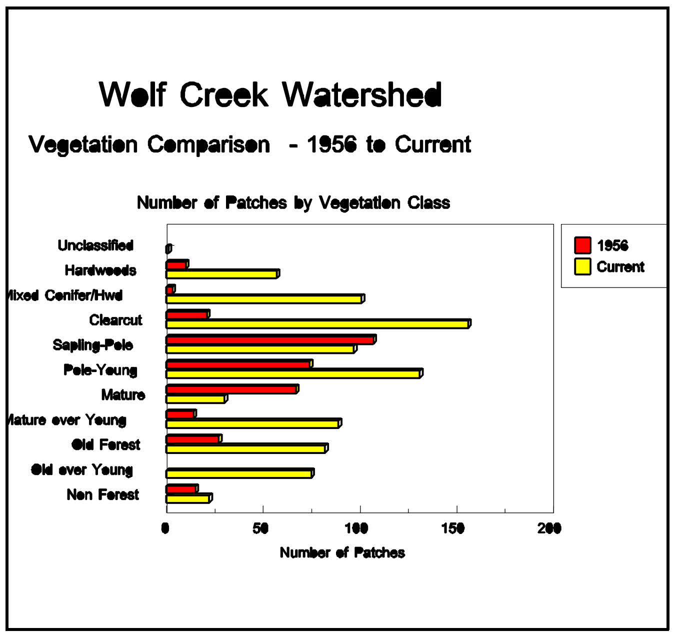

Figure 2: Changes in the number of forest patches from 1956 to the present

Based upon the FRAGSTATS[3] information, the following tables summarize the major patch parameter changes for the Wolf Creek watershed.

Table 6-1 - Patch Metrics

Patch Metrics	As of 1956	Current Condition
Number of Patches (number)	229	819
Patch Density (no. per 100 acres)	mature 0.15	clear cut 0 .42
Mean Patch Size (acres)	165.5	46.3

Table 6-2 - Individual Patch Type Information - Current Conditions

Patch Type	Total Acres	Largest Patch Index (LPI - %)	Number of Patches	Patch Density (no per 100 acres)	Avg. Size (acres)
Unclassified	35.3	0.09	1	0.00	35.4
Rock Patches	211.9	0.29	32	0.08	6.6
Ponds and Bogs	38.8	0.04	24	0.06	1.6
Nonforest - altered patches	374.7	0.26	22	0.06	17.0
Hardwoods	2,326.0	1.67	59	0.16	39.4
Mixed Conifer/Hardwood	1,815.5	0.34	98	0.26	18.5
Clear cut	9,108.2	2.10	162	0.43	56.2
Sapling-Pole	4,117.8	1.10	102	0.27	40.4
Pole-Young	10,270.8	3.28	120	0.32	85.6
Mature over Young	2,608.9	1.13	86	0.23	30.3
Mature	349.3	0.15	30	0.08	11.6
Old over Young	1,844.2	0.53	72	0.19	25.6
Old Forest	4,789.4	0.79	83	0.22	57.7

The patch heterogeneity or within patch variability is another descriptor of patch characteristics. Two habitat elements that contribute to variability between the same patch type as well as among patch types are snags and downed logs. There is no information historically available for snags and logs but, based upon the work done in the wildlife section (see Chapter 5) of this analysis, current snag and downed log estimates are available. Table 6-3 summarizes the snag and downed log information currently available.

The youngest patch type where snag estimates were possible is the mature and mature over young, approximately 80 years plus in age. The estimate of snags per acre is less in both 2-storied stand types. This is primarily because these stands are the result of some form of past timber management, partial cuts, or salvage logging after the Columbus Day wind storm. The snag numbers in these previously entered patch types are currently sufficient to support the 40 percent population levels for woodpeckers; however, snag number are expected to decline in the future as the current ones decay. This poses a potential problem. The diameter estimate of the snags is supportive of the past management activities with the mature over young type having snag diameters approximately the same size as the old forests in spite of the age differences. The snags found in the old over young patch type are generally from the oldest age class found in the type. The diameters correspond to the snag size found in the old forest type.

The snag estimates in the mature and old forest types are more typical of the numbers expected in these patch types throughout the watershed. The mature type has smaller diameter snags compared to the old forest, This is because the majority of the mature stands have developed naturally, with the snags currently in the mature patches being the result of competition related mortality. The old forest patches have aged more and the snags present in this type are the result of a variety of mortality agents: competition, windfall, disease, etc. Even though the snag numbers are currently sufficient to support the 40 percent level of woodpecker populations, there are generally fewer snags than expected for these aged stands according to work done by Franklin et al. [4] Even though this work was based in the central Cascades, the snag numbers found in the Wolf Creek watershed are less than that determined for old forest stands in the Cascades (24 in the Cascades versus 6.2 in Wolf Creek). Since the minimum snag size differs between the sources, it is difficult to determine what an appropriate baseline number for snags should be for these patch types. Work done in the Coast Range by Cline et al.[5] suggests that the snag numbers in Coast Range stands are significantly less than the Cascades. Cline found 13.9 snags per acre greater than 3.6 inches in diameter in 120-year old Coast Range stands and 7.3 snags per acre in 200-year old stands. Given that Table 6-3 represents snag numbers that are 11 inches diameter and greater, the numbers appear to be more representative. Cline estimated that between 65 and 89 percent of the snag numbers reported were less then 7.4 inches in diameter. Using these percentages to roughly correlate the 2 data sources, Cline found between 1.5 and 4.7 snags per acre greater than 7.4 inches in diameter. The numbers estimated for the Wolf Creek watershed exceed this range. This leads to the conclusion that the current snag population estimates for the mature and old forest types in the Wolf Creek watershed meet or exceed expected snag numbers reported from other Coast Range areas.

Table 6-3 - Summary of Habitat Structures for Current Forest Types

Forest Patch Type	**Snags**		**Downed Woody Debris**		
	Average DBH (inches)	**Snags per Acre**	**Average Diameter (inches)**	**Lineal Feet per Acre**	**Tons Per Acre**
Pole-Young	N/A	N/A	9	961.8	11.35
Mature over Young	30.5	2.4	15	1,036.0	42.00
Mature	18.9	6.2	12	1,923.6	42.05
Old over Young	36.8	3.4	14	2,015.2	57.90
Old Forest	37.8	4.1	16	1,338.2	45.12

The estimates of downed wood vary between patch types as expected. The old over young patches have the greatest lineal feet and tons per acre of downed wood, and the pole-young patches have the smallest amount. The downed wood produced in the pole-young type is primarily the result of stand density related mortality as the average log size of 9 inches fits these stands well. Franklin et al.[4] reports from 38 to 85 tons per acre of downed wood as typical of old growth forests in the Cascades. The older forest types in the Wolf Creek watershed fall on the lower end of this range.

Matrix

The matrix represents the most extensive and connected patch type in the watershed. The matrix is generally the predominant vegetation or patch type and exerts the most control over the movement of living and nonliving things (water, wind, fire, plants, animals, people, etc.) across the landscape. The rate at which these things move across the watershed is controlled by the matrix. The origin, stability, and pattern of the matrix are important factors to understanding the role of the matrix.

In the Wolf Creek watershed the entire basin is a mixture of the different patch types, with 2 patch types dominating the landscape: pole-young and clear cut. Based upon a variety of landscape area metrics available in FRAGSTATS, the pole-young patch type is the most dominant type with clear cut/early seral stages as the second most dominant type. The pole-young patch type occupies 27 percent of the watershed, the largest percent of the landscape of any of the patch types, and has a largest patch index (LPI) of 3.91. The LPI is an index that quantifies the percent of the total landscape area occupied by the largest patch of that type. The clear cut type occupies 24 percent of the basin and has an LPI of 2.1.

Origin - The origin of the pole-young patch type in the Wolf Creek watershed has largely been the result of timber management practices in the recent past, and human settlement previous to that. The clear cut patch type has resulted from logging and forest management within the last decade. Some of the differences between the matrix existing in the watershed currently and one created by "natural" causes are:

1. fewer numbers of snags remaining, especially in the larger diameter classes.
2. more soil disturbance from road construction, logging, and other land management activities.
3. reduced size, amount, and distribution of downed woody debris and logs.
4. differences in pattern and spacing in individual trees as a result of hand planting rather then a more random pattern and spacing typical of natural reforestation.
5. quicker site occupancy by tree species resulting in less time in the "clear cut" patch type where forbs, grasses, shrub, and hardwood species are more prevalent. This reduces the complexity of species composition within the stands and limits availability of certain habitats.
6. faster rates of change between seral stages as a result of silvicultural treatments and manipulations.

Stability - The landscape stability is the likelihood that a landscape structural element will change significantly in composition, features, etc. over time and the rate of that change. Since the matrix exerts the most control over movement of living and nonliving things within the landscape, the stability of the matrix is a good characterization of the overall stability of the landscape. The Wolf Creek watershed is dominated by pole-young and clear cut patch types, which are early successional stages. Early successional patch types are generally unstable as the rate of structural change is relatively rapid when compared to the more stable, slowly changing old forest types. As a result, the Wolf Creek Basin is unstable and subject to more rapid changes in landscape structure in the future.

Pattern - The pattern of the current landscape matrix in the Wolf Creek watershed is largely influenced by the checkerboard ownership pattern. The BLM manages 44 percent of the area and has 88 percent of the old forest remaining within the basin. The matrix types (pole-young and clear cut) are present in amounts equal to or slightly less than the amount of BLM ownership. The matrix within the Wolf Creek watershed is equally distributed within the boundaries. The remaining old forest patches, however, are mostly present in the middle and western portions of the basin.

Changes Over Time - Based upon the historical vegetation conditions discussed in a previous section, the Wolf Creek watershed has historically been a matrix of old forest, at least from the turn of the century. The 1956 vegetation conditions indicate that even then, about 30 percent of the basin was still in old forest conditions. The matrix within the Wolf Creek watershed has shifted from a relatively stable old forest dominated landscape to a much more fragmented, dynamic and unstable pole-young and clear cut controlled landscape.

Patches

Patches in a landscape context are areas distinctly different from the surrounding landscape. In the Wolf Creek watershed the patches have become the older forest areas remaining in the basin as well as the nonforested areas. The older forest areas are composed of 4 separate patch types: mature forest, mature over young, old forest, and old over young.

Origin - The origin of the 4 older forest patch types is more than likely natural. However, the mature over young and old over young patches have been influenced by past human actions. It is difficult to determine, but some of these patches have been influenced by past salvage logging, wind storms, settlement, low intensity fires, or are remnants from some of the earliest logging in the watershed. The mature and old forest patches were largely naturally regenerated stands with their origins in the early to mid-late 1800s. The altered patches are all the result of human activities such as settlement, farming, and rock quarry development.

Stability - The mature and old forest patches are generally more stable landscape structures. The older the stand or patch, the less likely that structural and compositional elements will change drastically over time. The rate of that change is usually slow. However, given the smaller size, isolated positions, the fragmented pattern within the matrix, and high edge contrast with adjacent patch types, the stability of these patch types has been decreased. The mature and old forest patches are now more susceptible to disturbance and have a higher likelihood that changes could occur. The old over young and mature over young patch types are even less stable and are probably more like the sapling-pole or pole-young patch types that dominant their understory in terms of overall patch stability. The older forest portion of these patches are primarily remnants of the original forest and offer some habitat value to old growth dependent species, but these patches are not a substitute for the old and mature forest types.

Pattern - The majority of the old and mature forest patches within the Wolf Creek watershed are located on BLM lands: 88 percent of the old forest type and over 50 percent of the mature forest type. The mature over young and old over young patch types are split between federal and private owners within the basin with the private ownership having a slightly greater percentage. Almost all of the altered patches occur on private lands.

The older forest patches are scattered throughout the basin as small, isolated patches. The larger patches occur in the western half of the watershed on BLM lands. These patches create a high degree of edge contrast with the adjacent forest patch types. The landscape has become more porous and fragmented from this distribution pattern. The old over young and mature over young patches are scattered throughout the watershed and are also somewhat isolated patches. The edge contrast with these patches is not as severe as with the older forest patches. The altered patches are predominantly in the eastern portion of the basin.

Changes Over Time - The patches have changed over time from clear cuts, sapling-pole, and pole-young to the older forest types. In 1956 clear cuts were about 4 percent of the total watershed area and currently occupy almost 24 percent. The sapling-pole type covered about 26 percent of the Wolf Creek watershed in 1956 and 11 percent today. This is trending toward a more porous landscape with a high degree of fragmentation of what historically was the matrix. A reversal has occurred in the vegetation that composed the matrix versus the patches resulting is a less stable landscape pattern.

The current pattern has probably changed the environmental conditions (light, temperature, humidity, and wind) within the older patches resulting in a drier, warmer, and windier microclimate along the edges.[6] A 500-foot wide strip along the edge of these patches is affected by these changes and, as such, has caused some changes in the species mix, and density of shrubs and herbaceous species.

Corridors

Corridors provide travel routes for plants, animals, and people between patch types. There are 2 major corridor types within the Wolf Creek watershed: line and riparian or stream corridors. Line corridors are narrow bands with high edge contrast that tend to be dominated by edge species. This type of corridor has a small/narrow central core that is essentially barren of terrestrial plants and animals and a high (chronic) disturbance frequency. Another type of line corridor exists in the Wolf Creek watershed and that is narrow stream buffers. Narrow stream buffers left along streams where timber harvest has occurred have the same characteristics of line corridors: high edge contrast and little central core area.

Stream corridors are the band of vegetation along streams that differ somewhat from the upland vegetation and/or matrix if present. These corridors may cover the edges of stream channels, the stream banks, part or all of the flood plain, and some of the upland transition area. The width of stream corridors vary from stream to stream based upon stream order, gradient, flood stages and frequency, and channel confinement. Stream corridors and Riparian Reserves have major landscape and ecological functions. Some of these functions include controlling water runoff, providing bank stability, reducing sedimentation, controlling mineral nutrient flows, and providing travel and movement corridors for terrestrial plants and animals. The purpose of the Riparian Reserves LUA is to establish stream corridors and provide some of these functions.

Roads - Roads are line corridors. Roads serve as breaks in landscape features and barriers to travel or migration of some species. The chronic disturbance results from repeated use by people as well as periodic road maintenance. The Wolf Creek Basin currently has over 330 miles of road within its boundaries or about 5.6 miles of road per square mile of area. These roads include all types from 2-lane paved county roads to natural surface (dirt) logging roads. The road control or ownership also includes BLM, Lane County, and private logging and access roads.

Changes Over Time - The changes in road density over time have been dramatic. The road density in the Wolf Creek watershed as of early 1950s was determined from aerial photos. Figure 22 illustrates the changes in roads over time. The road density in Wolf Creek watershed has increased from 88.9 miles of road in 1956 to 333 miles. The road density in 1956 was 1.5 miles of road per square mile compared to today's density of 5.6 miles per square mile. This represents an increase of about 380 percent over 37 years.

Landscape Stability - The stability of the landscape has been affected by the increase in roads. Larger blocks of habitat have been opened up as the result of roads allowing for more human disturbance; decreasing the overall patch stability by making them more prone to windthrow and other disturbances like insects, disease, and to some degree human caused fire; changing the species composition of these blocks by providing conduits for noxious weeds as well as alteration of the environmental conditions; and increasing the amount of exposed soil for potential erosion and landslides resulting from construction.

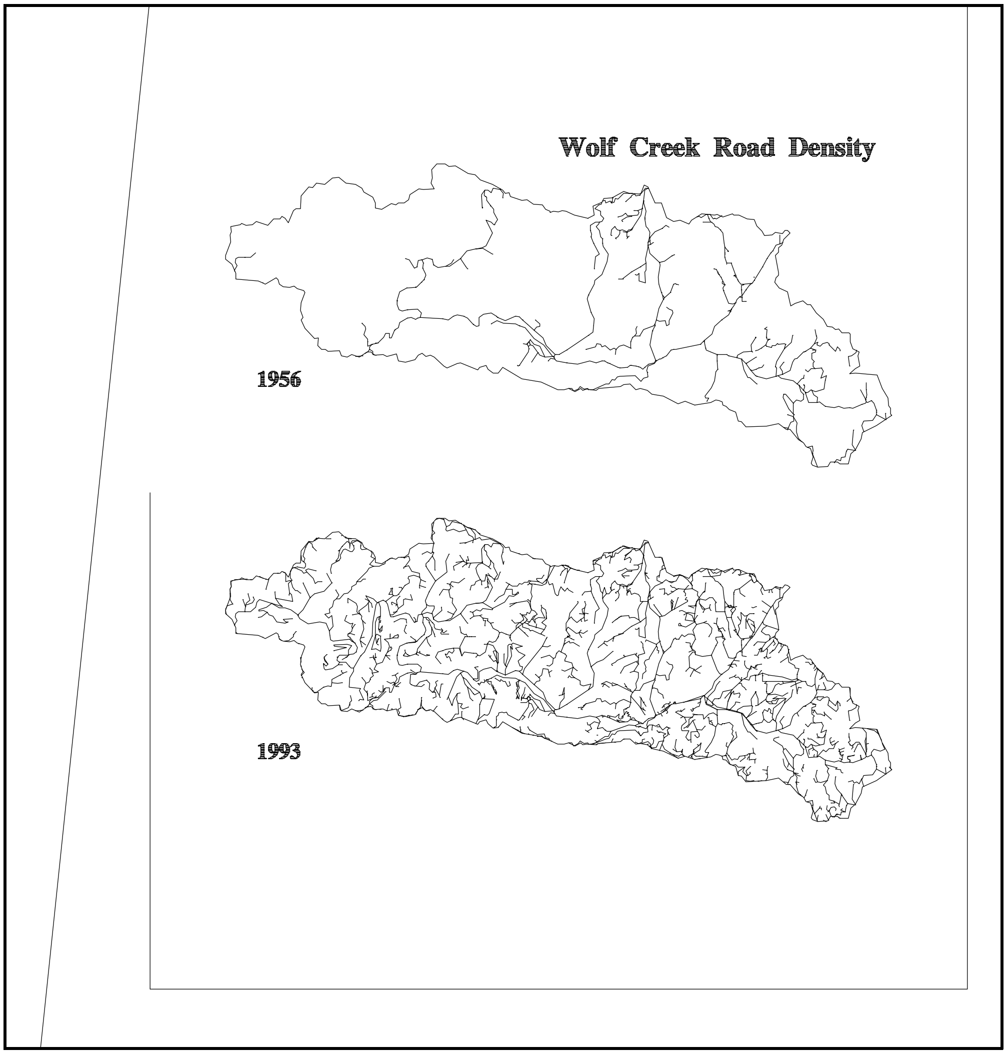

Figure 3: Changes in Road Density Over Time - Wolf Creek Watershed

Streams - Wolf Creek flows generally through the middle of the watershed. Wolf Creek varies from a 1st order stream in the headwaters to a 5th order stream at its confluence with the Siuslaw River. There are several major tributaries to Wolf Creek within the basin: Swamp Creek, Panther Creek, Eames Creek, Grenshaw Creek, Oat Creek, Pittenger Creek, and Saleratus Creek. There are 354 miles of perennial streams within the watershed.

Riparian Areas - The riparian vegetation section in Chapter 5 detailed the available information. In general, human actions have changed the vegetation communities associated with the riparian zones of all of the major tributaries within the basin. The ownership pattern influences the presence or absence of streamside buffers with harvesting occurring down to the water's edge in some areas. Wolf Creek road parallels Wolf Creek for a majority of its length, crosses Wolf Creek in several locations, and is within the riparian area of Wolf Creek for at least 50 percent of the length. The resulting pattern of roads, some buffers, no buffers, and varying buffer widths along sections of each creek has produced a poorly connected riparian corridor. A lack of older forest types in the riparian vegetation is a major limitation in the ability of these areas to provide wood inputs to the aquatic system.

Landscape Flows

"Flows" are those things that move across the landscape. Flows can be biological, physical, or energy and may move over large parts of a watershed or be confined to distinct corridors or patches. The flows interact with the landscape elements as well as the landscape as a whole. Flows into, through, and out of the Wolf Creek watershed, are very important to the biological diversity and genetic diversity necessary for a proper functioning ecosystem. Without these flows or movements, the ecosystem slowly begins to break down and becomes genetically monotypic with consequences of potential extirpation and extinction of many fish and wildlife species. To prevent these consequences, it is necessary to maintain and possibly increase flows of genetic diversity, and to reestablish flows that may have occurred but currently are absent.

There are an infinite number of things that move/flow through a landscape but we are concerned only with those flows that are critical to the future landscape and most likely to be affected by human actions. The following flows were identified as important within the Wolf Creek Basin:

< Water and sediment
< Fish and aquatic organisms
< People
< Wildlife (spotted owls, marbled murrelets, and elk)

Water - Water enters the watershed as precipitation, primarily as rain during winter storms. A small amount enters in the form of fog drip, a process of fog capture by vegetation that drips to the forest floor. Eighty-two percent of the precipitation occurs from October through March. From 10 to 30 percent of this water is captured by vegetation and evaporates. A small portion of the precipitation falls directly into streams (about 0.2%), or flows overland to streams (about 0.2%). As much as 98 percent of the precipitation that reaches the ground infiltrates into the soil to become ground water. A small percent of the ground water enters the bedrock, flows slowly and finally emerges as stream flow in creeks or rivers. An insignificant portion of this flow will leave the watershed as groundwater and surface in the Siuslaw River.

The vast majority of the water enters the soil where it becomes part of the soil ecosystem. The water becomes part of the above ground ecosystem as it moves through mycorrhizae and roots into plants, it moves into, out of, and through the O horizon or duff layer; it moves as part of animals, and moves out of the soil ecosystem by transpiration of plants or evaporation from exposed soil surfaces. Most of the water is not available to the soil ecosystem because there is little biological activity in the winter, and because the soils are very permeable allowing the water to flow downhill. For these reasons there is a summer drought. Most plants including the trees only grow for a few months in the spring.

Water that falls after field capacity has been reached, along with water that enters the soil near creeks without riparian areas, joins the surface runoff and the antecedent water in the creeks to become part of the peak flow. Water that is not lost to evapotransporation or to flood runoff moves slowly downhill as ground water until it reaches a stream channel. Except for a minor amount that is lost to evaporation, the water that reaches a stream moves through the channel system and empties into the Siuslaw River at the mouth of Wolf Creek (see The Aquatic Ecosystem in this chapter).

Fish - Fish and other aquatic organisms that flow into, out of, and through the watershed are primarily linked to the existing stream channels. Anadromous fish that migrate into the Wolf Creek main stem and its tributaries from the Siuslaw River perhaps make up the largest and most active component of aquatic ecosystem flows. As discussed in the Fisheries section of Chapter 5, there are 5 major species of anadromous fish that migrate into the Wolf Creek system: chinook salmon, coho salmon, steelhead trout, sea-run cutthroat trout, and pacific lamprey. Of these species, steelhead, cutthroat, and lamprey flow back out of the system. Chinook, coho and lamprey come into the system to spawn and die afterwards. Thiry-five to fifty percent of the nutrients from these dying fish go to the riparian vegetation. The remainder of the carcasses become food for juvenile salmonids, predators or scavengers, or flow through other avenues in the decomposition process. On the other hand, steelhead and cutthroat do not die after spawning and return to the ocean. Eggs left by all these fish develop into young fish and move out of the stream system to the ocean, returning in subsequent years to continue the cycle.

Native runs of salmonid fish generally return to their "home" stream; however, some fish (-5%) naturally stray to other streams, which helps reduce genetic isolation. Each stream over time develops a unique genetic profile. Use of hatchery fish has disrupted the natural profile, introducing a new set of genetic material.

Other aquatic organisms include, but are not limited to, macroinvertebrates that flow into and out of the Wolf Creek watershed via streams and short overland migrations. Flows by such macroinvertebrates include the development of adult flying insects from aquatic larvae, which may fly and disperse out of the watershed or throughout the watershed. Many invertebrates can only move in small geographical areas and are limited to stream courses for migration. When barriers develop, genetic dispersal is limited and unique sub-species or species may form. There are 3 Special Attention Macroinvertebrate (FEIS, J2 Appendix species)[7] species located from a survey of 5 locations in the main stem of Wolf Creek. However, these surveys were cursory only and it is unknown how many of these species exist and in what densities. Additionally, how these species interact with the micro-ecosystems in Wolf Creek is not currently known.

People - Flows of people through and within the landscape are determined by access and activity. Access, meaning roads in the case of the Wolf Creek watershed, defines where and how nearly all human flows occur within the landscape. When people move through the landscape (daily and seasonally) is defined by activities. Intensity of human flows is also dependent upon activities and can vary substantially over time (for example, assuming a 35-year timber harvest rotation, intensive human use and people flows associated with timber harvest activity might be concentrated in a particular part of the landscape for a few months every 35 years or so).

There are 3 important human flow regimes operating in the landscape. The most significant of these is associated with residential use of the Wolf Creek and Panther Creek road corridors. On a daily basis, people move out of the landscape, generally to the north, along Wolf Creek road during the morning, and return by the same route to reoccupy residences in the afternoon or early evening. Also associated with the residential uses is service traffic (mail, household deliveries, etc.). During a typical day there will also be people movement between residences along these corridors. The fairly constant human movement within the corridor may interrupt or discourage other flows.

Another human flow regime occurs with timber management activities in the form of forest workers and log trucks and other equipment moving to and from forest work sites. Such flows can be intensive for short periods (a few weeks) but typically do not affect any one area for extended periods, and normally occur during daylight hours. The major haul roads (B-line, C-line, etc.) and Wolf Creek road are the corridors where most of this activity typically occurs.

A third important human flow regime occurs seasonally and is associated with the big game hunting season. The Wolf Creek watershed is popular for deer and elk hunting. During the fall, people (hunters) move along all open roads within the watershed, and concentrated use occurs along the main timber haul roads.

Other people flows associated with such activities as dispersed recreation, road maintenance, routine forest management, etc. occur within and through the watershed following the same access-dependent patterns as occur with the previously mentioned human flows. These flows occur intermittently throughout the year.

Wildlife - Terrestrial flows are more variable and widespread. Terrestrial wildlife species are not limited to a specific resource like streams and are able to move across the landscape in a variety of manners and distances. There are several wildlife species that may migrate into, through, and out of the watershed. These include Roosevelt elk, cougar, black-tailed deer, black bear, several rodent species, several species of amphibians, and a large number of birds. There have been many sightings of elk in the western half of the watershed and just outside the western boundaries of the watershed. These sightings indicate that elk move into and out of the watershed in many locations. This is probably true for black-tailed deer and, because of the large territories that cougars and black bears use, the potential for their movement into and out of the watershed is high. Movement for many of the other smaller species of wildlife, except birds, is probably limited to the protection that they gain from the different habitat types occurring in the watershed. Amphibians move relatively slowly and for short distances, primarily through areas that give protection and the necessary elements for survival (moist soils, duff layers, high canopy cover, etc.). On the other hand, birds move readily into, through, and out of the watershed. There has been at least one sighting of a bald eagle in the watershed, even though there is no known nest or roost locations. There have also been several sightings of other birds of prey, either flying across, through, into, or out of the watershed. For those birds that do not exclusively use stands of trees for cover there is no limit to their ability to move through the watershed.

Spotted owls, known to occupy the watershed, concentrate most of their movement during the nesting season within approximately 1 mile of their nesting or core area. Movement into or out of the watershed during that time is very limited. During the non-nesting period, spotted owls will increase their home range by as much as 400 percent. This activity will undoubtedly bring the owls to other portions of the watershed and the potential for them to move out of the watershed is very high. Furthermore, young owls, either dispersing juveniles or non-paired sub-adults, will travel long distances to locate an area that is either unoccupied by other spotted owls or is occupied by a single owl of the opposite sex. This movement may bring owls to the watershed from long distances, owls may move out of the watershed, or owls may just pass through the watershed.

Marbled murrelets are presently not known to occupy areas within the Wolf Creek watershed. However, there is documented occupancy near the mouth of Wolf Creek at the western edge of the watershed. These sea birds travel inland during the nesting season to locate and establish a nest site. Once the nest location has been established and an egg laid, both adults incubate the egg in alternating 24-hour shifts until the young have hatched. The adult not occupying the nest spends that time in the ocean feeding, and returns to the nest location just prior to sunrise where it replaces the other adult. After the young have hatched, both adults spend the day feeding in the ocean and return just prior to sunset to bring food to the young. Because of the distance that murrelets are currently known to travel inland, some areas are not likely sites for murrelet occupation. The Wolf Creek watershed is located entirely within the distance established for murrelet occupation, and may have murrelets passing through the watershed or stopping in the watershed. Until complete surveys have been conducted on potential nesting habitat, it is unknown whether marbled murrelet occupancy occurs in the watershed.

Interactions and Linkages

The following tables (matrices) attempt to identify the interactions and links between the various landscape structural elements and processes with the flow elements identified within the watershed. The primary purpose of these matrices was to assist the team identify the linkages and interactions between some of the major landscape elements, develop a sense of importance or priority between these linkages, and to focus the discussion. Each of these interactions will be explained in more detail later.

The aquatic flows and linkages will be discussed in the aquatic ecosystem section, but the focus will primarily be on fisheries and stocks at risk as well as water quality and quantity. These 2 areas were each a major issue as identified in Chapter 4. The terrestrial linkages will be analyzed in the terrestrial ecosystem section. The discussion will address the issue of wildlife habitat, fragmentation, connectivity, and special status wildlife species. The human interactions were not one of the major issues but are integrally related to the biological issues. How the social system interacts with the landscape pattern and elements identified in the Wolf Creek watershed are discussed under the social system.

Table 6-4 - Aquatic System Flows and Linkages

Landscape Element/Process		**FLOW ELEMENTS**		
		Water	**Sediment**	**Fish**
Matrix	Pole-Young	affects flows		
	Clear cut	affects flows		
Patch Types	Old Forest	affects flows		
	Old over Young	affects flows		
	Mature	affects flows		
	Mature over Young	affects flows		
	Sapling-Pole	affects flows		
	Mixed Conifer/Hardwood	affects flows		
	Hardwood	affects flows		
	Rocky Patches	- increases run-off - affects flows		
	Ponds and Bogs	affect temperature and flows	filtering and sediment storage	- refugia - rearing habitat
	Altered Patches	- increase water demand - may affect flows	potential sediment source	- barriers, poaching, predation - source of nonnatives - sediment source
Corridors	Roads	affects flows and routing	potential sediment source	barriers, sediment source, and poaching
	Riparian Areas	affects temperature, flows, and sediment delivery	- potential sediment source - capture & filtering of sediment	structure source for habitat
	Streams		affects routing	-primary habitat - migration routes
Mass Wasting		affects water routing	major sediment source	provides sediment, gravels, boulders, woody debris for habitat
Hillslope Erosion			supplies fine sediment	embedding of spawning gravels

Landscape Element/Process		FLOW ELEMENTS		
		Water	Sediment	Fish
Channel Morphology		affects flows and dissolved O_2	affects sediment routing	- habitat distribution and composition - migration
Flows	Peak and Base	affects temperature and dissolved O_2	affects amount of sediment and carrying capacity	- refugia and rearing habitat - migration
Sediment		affects water quality		fines detrimental, coarse beneficial
Stream Temp		affects water quality		high temperatures lethal
Soil Productivity				

Table 6-5 - Terrestrial System Flows and Linkages

Landscape Element/Process		FLOW ELEMENTS		
		Spotted Owls	Murrelets	Elk
Matrix	Pole-Young	- roosting, foraging, dispersal habitat - primary dispersal habitat	nonhabitat	hiding cover
	Clear cut	barriers to movement	nonhabitat	forage and exposure to hunting
Patch Types	Old Forest	primary habitat	critical habitat	optimal cover
	Old over Young	- roosting, foraging, dispersal habitat - important for dispersal	non habitat	thermal cover
	Mature	important habitat	nonhabitat	optimal cover
	Mature over Young	- important for dispersal - roosting, foraging, dispersal habitat	nonhabitat	thermal cover

Landscape Element/Process		FLOW ELEMENTS		
		Spotted Owls	Murrelets	Elk
	Sapling-Pole	barrier to movement	nonhabitat	hiding cover
	Mixed Conifer/Hardwood	- roosting, foraging, dispersal habitat	nonhabitat	thermal cover
	Hardwood	- roosting, foraging, dispersal habitat	nonhabitat	thermal cover
	Rocky Patches	potential foraging habitat	nonhabitat	potential forage
	Ponds and Bogs	non habitat	nonhabitat	- wallows and water sources - travel barriers
	Altered Patches	non habitat	nonhabitat	- travel barriers - poaching - foraging
Corridors	Roads	low impact		disruptive, barriers
	Riparian Areas	important for dispersal	possible migration routes	- thermal cover - foraging - migration routes
	Streams		possible migration routes	watering and thermal regulation
Mass Wasting				
Hillslope Erosion				
Channel Morphology				possible barriers to travel
Flows	Peak and Base			high flows are a barrier to travel
Sediment				
Stream Temp				
Soil Productivity				forage quality

Table 6-6 - Human Flows and Linkages

Landscape Element/Process		Human Interactions
Matrix	Pole-Young	screens visual opportunities
	Clear cut	- provides viewing opportunities - hunting and gathering - aesthetics: unpleasant to some

Landscape Element/Process		**Human Interactions**
Patch Types	Old Forest	- commercial value and products - collecting opportunities - aesthetics and spiritual experiences - study and research
	Old over Young	- some commercial value - limited recreational value
	Mature	- commercial value - hiking and recreation - gathering - study and research
	Mature over Young	- some commercial value - limited recreational value
	Sapling-Pole	screens visual opportunities
	Mixed conifer/Hardwood	- seasonal value: fall colors and aesthetics - hunting and gathering - limited commercial value
	Hardwood	- aesthetics - hunting and gathering
	Rocky Patches	- aesthetics - botanical interests and study
	Ponds & Bogs	- aesthetics - barriers to travel - use by domestic animals
	Altered Patches	- water rights and uses - residential development - commercial value: real estate and quarry rock
Corridors	Roads	access and routes of travel
	Riparian Areas	- aesthetics - camping and picnicking
	Streams	- water contact activities and recreation - may impact fish structures

Landscape Element/Process		Human Interactions
Mass Wasting		- could affect transportation and access - could reduce use - could damage man-made structures: bridges, roads, trails, etc
Hillslope Erosion		
Channel Morphology		recreation opportunities
Flows	Peak and Base	- water rights - high flows may reduce recreational uses - high flows may affect property values - could damage man made structures - affects engineering requirements - affects commercial fisheries values
Sediment		- affects water rights: drinking water - decreases aesthetics - decreases recreation
Stream Temp		- impacts fishing opportunities - impacts recreation uses
Soil Productivity		influences agricultural crops

The Aquatic Ecosystem

Hydrologic Function - The hydrologic relationship between the creek, the riparian area, and the flood plain are so interrelated and complex that it is difficult to separate them. Water that is not lost to evapotransporation or flood runoff moves slowly downhill until it reaches a stream channel or flood plain. Flood plains and their associated riparian vegetation are a critical part of the hydrologic functioning of a watershed. Hydrologically riparian areas connect and are part of the terrestrial and the aquatic systems. Flood plain soils are deep alluvial soils that store the water from the uplands and in periods of high flow store water from the creek. This water is slowly released in the summer resulting in greater soil moisture in the riparian area and greater base flow in the creek. The higher soil moisture in riparian areas produces a greater diversity and abundance of flora and fauna than in the uplands. The increased vegetation produces denser root masses, more litter and dead wood; all of which helps store water. The increased shade and evapotransporation of the riparian area and the creek creates a micro climate that has higher humidities and more moderate temperatures than the surrounding uplands. At one location, humidities were measured on an upland clear cut of 26 and 48 percent in the undisturbed riparian zone. The temperature on the clear cut was 94ºF. and 75ºF. in the riparian zone. The change in microclimate in turn changes habitat for the biologic community, which changes soil water movement and microclimate.

Water flows from the creek in the winter and spring and flows to the creek in the summer and fall. The structure, composition, morphology, and therefore, the functioning of physical and biological processes of riparian areas are created largely by the creek. Likewise the structure, composition, morphology, and therefore, the functioning of physical and biological processes of creeks are created largely by the riparian area.

Peak flows cause the creeks to overflow their banks and inundate the flood plain. These floods can cause the following to occur:

1. If there is not adequate structure in the creek and/or riparian area, the channel bottom will erode and the stream will down cut. This will drain the riparian area and much of the riparian hydrologic functions will be lost. Downcutting

and/or unusually high peaks will cause the stream to straighten its course. This means that the stream will drop in a shorter distance, which will increase velocity and increase downcutting.

2. Adequate structure, including the riparian vegetation will decrease stream velocity. This will result in deposition of sediments, which will result in a build up of the flood plain and channel bottom. In stream structure will divert the flow, which will cause bank cutting and meandering. The result will be:

   - Deeper flood plain soils for water storage and plant growth;
   - Raised channels that reach the flood plain more often and transfer water to the riparian area more efficiently;
   - Greater sinuosity that results in more creek/riparian contact, greater riparian area and slower velocities;
   - Changes on channel location that create back waters and other aquatic habitats;
   - More and deeper pools;
   - Disturbance of the riparian area for young serial stage organisms;
   - Higher base flows and less damage from future peak flows.

Channel Morphology and Flows - The basic make-up or morphology of a stream channel can affect the composition and distribution of fish habitats in a stream system as well as the availability of those habitats for fish. The more complex the stream morphology is the more habitat or structure available. Additionally the size, shape, and number of pools, riffles, and other fish habitat features are primarily determined by the base or minimum flows occurring during the summer months.

The channel morphology of the stream channels in Wolf Creek indicate that most of the smaller streams (1st and 2nd order) have good complexity and structure; thus providing good fish habitat. This habitat is primarily in the form of pool-riffle and step pool morphologies. However most, if not all of these stream segments, have high gradients and are inaccessible to anadromous fish species or other fish species.

Evidence of downcutting or entrenchment occurs on several 1st and 2nd order streams. Most of these reaches show little signs of entrenchment and only a few show extensive signs.

The larger streams in the watershed (3rd order and above) have few areas where adequate hydrologically functioning channels or riparian areas exist. Most of these streams have been downcut to bedrock, and seldom if ever reach flood plain levels. The exception is in the upper portion of Wolf Creek, where beaver activity and logging debris have brought the channel closer to natural levels. Degraded channels route the water more efficiently and may cause larger floods downstream, lower summer flows, lower riparian area groundwater tables, and higher velocities that prevent new structures from becoming established. By slowing the flow velocity and raising the water level, habitat components (gravels, cobbles, logs, etc.) accumulate along the stream and provide more habitat necessary for rearing and spawning anadromous fish species. The riparian groundwater tables may also rise.

The Wolf Creek watershed lacks an adequate supply of gravels, cobbles, and boulders. The channel substrate generally consists of sands or bedrock. This indicates that the morphology of the stream channels are very simple with little structure and few habitats. With the placement of several man-made structures along portions of Wolf Creek and its tributaries, there is a potential for accumulation of these limited substrate types. Introduction of gravels in the upper reaches of Wolf Creek is intended to excellerate the natural recovery process. This is considered to be only short term until the natural recovery process is established. Because gravels are naturally introduced in smaller amounts and over longer periods of time than those introduced by man made structures this habitat component may not naturally accumulate in adequate amounts for suitable fish habitat for 100 to 200 years.

The flows occurring through the Wolf Creek watershed range from base flows of approximately 5.57 cubic feet per second (cfs) to peak flows of 4,547 cfs. Higher flows can distribute and deposit habitat components down a stream system to areas with little or no structure present. These areas are primarily lower gradient portions of the tributaries to Wolf Creek near these streams' confluence with Wolf Creek. Additionally, high flows can flush a system clean of structure if the system has no mechanism to slow it down and allow the debris and material to accumulate. Since the channel morphology of the large streams in the watershed are entrenched, lack structure, and have a low water table, a high flow or peak flow through the system has the potential of pushing any structure and/or debris down to the mouth of Wolf Creek and scouring the channel. However, strategically placed man-made structures can increase the water table and can decrease the velocity of flow, almost eliminating this potential torrent. These structures will allow deposition of the habitat components necessary to provide habitat for rearing and spawning anadromous fish species.

Stream Temperatures and Riparian Zones - Water temperature in anadromous fish bearing streams is a primary factor in the use of these streams by fish. Water temperatures that are 64EF. and lower are considered suitable for salmonid fish. Fish can survive temperatures in the range of 64EF. to 68EF.; however, in these temperatures fish begin to develop an oxygen debt and they can only recover in cooler waters. Water temperatures greater than 68EF., and especially greater than 72EF., are considered to be lethal to salmonids [8].

Water temperatures in the main stem of Wolf Creek are considered to be relatively high, often exceeding 68EF. Historically water temperatures were as high as 80EF., and ranged from 66EF. in the upper reaches to 80EF. in the lower reaches to the mouth (from thermograph readings taken in 1971). Temperature readings in 1986 show a range of 68EF. in the upper reaches to 74EF. in the lower reaches to the mouth[9]. This is probably due to the large amounts of bedrock substrate exposed to sunlight and the lack of vegetative cover along the streams. These elevated temperatures are ultimately transferred to the Siuslaw River at the Wolf Creek confluence. The Siuslaw is in a similar condition with a wide channel, limited vegetative cover, and exposed bedrock substrate. The intrusion of warmer waters into the Siuslaw River from Wolf Creek can only make conditions worse for rearing fish.

As the vegetative cover along the banks of the streams in Wolf Creek watershed continue to grow and provide shade, temperatures during the summer will continue to decline. By placing structures in the stream system, attempting to eliminate the exposed bedrock, and reducing the downcutting in the stream channels, the temperatures will decline as well.

Riparian zones are important not only for stream temperature regulation but also for the deposition of habitat components (down wood) to the stream system for fish habitat[10]. Ninety percent of the woody material that falls into a stream comes from within 100 feet of the stream,[11] thereby, increasing the importance of the riparian zones for stream habitat.

The riparian zones within the Wolf Creek watershed generally consist of fragmented forest communities with relatively small isolated patches having the potential for contributing large down wood to the stream system or providing adequate shade. Habitat types considered to have the highest potential for providing this material into the stream are the old forest stands, old hardwood stands, and mature forest stands. These forest types comprise approximately 26 percent of the riparian habitat types in the entire watershed (see Chapter 5, Riparian Areas and Conditions). Most of the areas that have these forest stands are located in the lower third of Wolf Creek main stem.

The condition of the riparian zones in the watershed dictates the current and future ability of the watershed to naturally provide habitat components, in the form of large down wood, to the stream system. With the current condition of the riparian zones in the Wolf Creek watershed, the natural introduction of large woody material into the stream system is limited to a very few areas scattered primarily along the main stem of Wolf Creek and in the western third of the watershed. This situation produces a limiting factor to the establishment of suitable fish rearing and spawning habitat in the upper two-thirds of the watershed. Currently the amount entering the channels is inadequate for proper accumulation.

The future availability of suitable sized woody material for the establishment of fish rearing and spawning habitat should improve over time. With the development of the younger stands to older stands and the establishment of Riparian Reserves along most of the streams in the watershed, the vegetative components necessary to provide large woody material in the stream system should increase. However, depending on the current age of those riparian stands, this future condition may not occur for at least another 80 to 100 years, and as long as 200 years.

To be certain that fish habitat meets the need for fish distribution in the watershed, consideration should be given to supplying wood via man-made structures in the upper portions of the watershed where components necessary for habitat structures are absent or very limited. In addition, structures should be established in the lower portions of the watershed to retain material that enters the stream system. At present, retention time of such material is short due to the lack of structure that holds material is place.

Altered Patches, Ponds, and Bogs - Approximately 6 percent of the riparian habitats are classified as altered patches. These include pastures, residential areas, and rock quarries. These areas can be both beneficial and detrimental to fish and fish habitat in the Wolf Creek watershed.

Pastures and residential areas can provide openings and access to a stream, allowing people to illegally harvest fish, or allowing people to illegally introduce exotic fish into a natural system. Additionally, these areas may supply contaminants to the water that may be lethal to native fish. Other potential impacts to fish from altered patches is barriers caused by livestock fencing across a stream, refuse and debris dumped into a stream, construction of roads and bridges, as well as irrigation structures that divert water from the main portion of the stream to areas that are inaccessible and unsuitable for fish. Additionally, these openings provide places for predators to hunt and capture fish, cause exposure to sun to fish, and inhibit fish passage from channel structures.

Altered patches may provide habitat components that otherwise would not be provided elsewhere in the stream. The rock quarries located near Wolf Creek may provide gravel, cobbles, and boulders to the stream quicker, during mechanized operations, than would naturally occur.

With the amount of area considered to be in altered patches near the streams in the watershed (6%), these types of habitats should not impair streams in the system. However, this impact is proportional to the existing habitat conditions. With fewer areas providing gravel, cobbles, and boulders to the streams, the rock quarry may add a significant amount of material to the system. The introduction of these substrates occur in the system, although sources are concentrated to only a few areas along Wolf Creek.

There are 17 ponds and 7 bogs along channels in the watershed. These are located in or near stream channels in the eastern half of the watershed, although several are man-made developments for live stock and other purposes. These areas are very important to the development of juvenile salmonids, as they provide stable water temperatures, food, and cover from predators such as birds and mammals. Additionally, these areas provide crucial water storing areas that help to stabilize flow and water levels, subsequently controlling the deposition of sediment downstream. With the concentration of these habitat types in the eastern portion of the watershed, the ability of the watershed to provide necessary food and cover for fish is limited. As discussed in the Fisheries section of Chapter 5, pools (including ponds) are very important to the overall "health" of a stream for fish. Most of the ponds in the eastern portion of the watershed are the result of beaver activity and have probably been established for quite some time. However, man-made structures properly placed have the potential for the same results.

Sediment - Sediment into a stream system can be introduced by several avenues. These include mass wasting (landslides), hillslope erosion, and road erosion. Each of these processes can beneficially contribute to fish habitat components within a stream system, or can detrimentally impact fish habitats. The following discussion relates the processes occurring in the watershed that introduce sediment to the stream system and how these processes affect (beneficially or detrimentally) fish rearing and spawning habitat.

As discussed in Chapter 5, the amount of habitat for fish spawning and rearing within the watershed is limited. These habitats are defined by the channel morphology, upslope activity, and streambed composition. In other words, the amount of spawning gravel in a system, for instance, is defined by where the gravel comes from and how much gravel is introduced.

Mass wasting, or landslide potential within the watershed can define what areas of specific streams are more likely to receive components for fish habitat from upslope disturbances. Mass wasting may cause streams to become inaccessible to fish by creating barriers to migration. However, these disturbances do not occur on a regular basis and appear to be aided by extreme amounts of precipitation or large-scale ground disturbing activities.

The mass wasting potential in the Wolf Creek watershed is most prevalent and highest in the western-half of the watershed. In the eastern-half of the watershed the mass wasting potential is low. The total amount of high mass wasting potential for the watershed is approximately 5 percent and the amount of low mass wasting potential is approximately 83 percent.

Debris flows are the prevalent type of mass wasting in the Wolf Creek watershed. Debris flows usually originate in headwall areas and scour high-gradient 1st and 2nd order streams. The debris flow material is typically deposited on downstream reaches with low gradients. Slopes of stream channels and tributary junction angles influence the travel distance of debris flows. Debris flows that move down steep gradient, straight channels tend to travel far. Debris flows that move down tributaries oriented at high angles to the main stem of a stream typically stop at the tributary confluence. Since most of the main tributaries (e.g., Saleratus, Bill Lewis, Pittenger, Gall) to Wolf Creek have low gradients, most debris flows would be deposited in these tributaries instead of travelling into Wolf Creek. Therefore, sediment and structure (large woody debris, gravel, and boulders) would be deposited in these main tributary channels. Debris flows that contribute sediment and structural materials directly to Wolf Creek typically would come from the smaller streams that flow directly into Wolf Creek. The debris flow that produced a debris deposit in Wolf Creek (T. 18 S., R. 8 W., Sections 25 and 36) in 1980 is an example of structural material provided directly to Wolf Creek from a smaller tributary stream.

Relating mass wasting to fisheries habitat indicates that most of the gravel, woody debris, and boulder input into the stream system potentially occurs in the western half of the watershed, those streams located west of Oat Creek. These are areas that have moderate to high potential for mass wasting because of the shallow soils with a rapid transition to hard, impervious bedrock. In the eastern half of the watershed, gentle to moderate slopes, soil cohesion, and less frequent and intense storms make mass wasting an insignificant process.

The introduction of gravels for spawning habitat and boulders for rearing and other habitats into streams in the eastern half of the Wolf Creek watershed will probably improve the fish habitat in the system. This type of habitat improvement is meant to excellerate the recovery process until the natural recovery process has become established. The upper reaches of the watershed does receive gravels into the system, although, this input occurs at a slower rate over a longer period of time. Coarse sediment (e.g., gravels and boulders) are more abundant in streambeds in the western half of the watershed due to hard bedrock close to the soils surface, steep slopes, and the occurrence of debris flows.

General surface soil erosion produces primarily fine sediments into a stream system. General surface soil erosion within the watershed is low, with 88 percent of the watershed having a low erosion potential. Less than 1 percent of the watershed shows a high potential for soil erosion. Based upon the findings in Chapter 5, hillslope erosion within the watershed is insignificant.

Soil erosion introduces fine sediments into the stream and potentially inhibits proper fish egg development by "suffocating" the eggs. Additionally, spawning gravels available to anadromous fish may become embedded with finer sediments causing those gravels to become unusable for spawning fish, depending on the rate at which these finer materials are introduced to the system.

The areas that are potentially high producers of fine sediments into the Wolf Creek watershed system contain soils that are most susceptible to erosion in a bare, tilled condition (high K Factor). These areas are located near Panther and Swing Log creeks, in the eastern third of the watershed, and comprise approximately 1 percent of the watershed. Areas that have moderate K Factors can also produce fine sediments into a stream system. Approximately 5 percent of the watershed has soils of this condition and they occur along Wolf, Panther, Swamp, Eames, and Oat creeks. Therefore, only a small portion of the watershed has a moderate to high potential of surface erosion when soils have no protective cover. This erosion could, depending on proximity to streams, produce fine sediments into the stream system.

In the mid-1950s roads were constructed in stream beds and logging was performed downhill to the roads. This scenario provided large amounts of sediment into the stream as indicated by large gravel bars shown in 1950s aerial photos. With current changes in forest management operations, the amount of roads in a given watershed may not produce significant amounts of sediment into the streams.

Most of the roads that produce sediment in the watershed are mainline haul roads that are rock surfaced and subject to moderate to heavy traffic and parallel the streams. Most of the sediment that is produced by these roads are finer sediments from road surface runoff. As discussed in Chapter 5, the amount of sediment currently produced into the Wolf Creek system by roads is approximately 5 to 10 percent of the background levels. This is considered low and produces no significant impact to the stream channel system.

Finer sediment production, either from hillslope erosion or road surface runoff, can impact the development of eggs and can embed available spawning habitat, which affects the potential fish reproduction capabilities of the stream. Because the amount of sediments into the stream systems from both of these processes is insignificant in the watershed, the impact to egg development should be insignificant as well. Furthermore, not only does the buildup of finer sediments impact fish spawning habitat, it can impact the ability of a stream to provide habitat for other aquatic organisms (macroinvertebrates) important to the proper function of an aquatic ecosystem.

Wolf Creek and much of the Siuslaw is and was low-gradient streams dominated by finer sediment materials. The native aquatic communities have adapted to these conditions. Additionally, the wide gravel/silt flats were part of the natural system with much of the sediment stored in the system helping to create the valley floors. The loss of structure has caused secondary channelization, which lowers groundwater levels and facilitates the export of sediments.

The Terrestrial Ecosystem

Patch Types - As indicated previously under patch types, there are 12 major types of habitats that have been identified in the Wolf Creek watershed: 9 forested and 3 nonforested types. These classes are essential for many wildlife species to meet some or all of their life requirement needs. The major species of wildlife that this discussion will involve are: spotted owls, marbled murrelets, and Roosevelt elk. The discussion will show the relationships between the wildlife existing in the watershed and the habitat that currently exists.

Spotted Owls - Old growth forest stands are among the most important habitat types within the watershed because of their complexity and diversity. This is reflected by the diverse number of wildlife species that require old growth forests for many of their life requirements. The watershed contains approximately 4,789 acres of old forest within its boundaries. Because spotted owls rely so heavily on old growth forest for nesting habitat, these old forests are the primary and often critical habitat for spotted owls. Of the 10 spotted owl sites located within the watershed, 9 of them are located within these old forest stands. There are currently 83 patches of this habitat type in the watershed, with an average patch size of 57.7 acres with a standard deviation of 71.6 acres (see Table 6-2). The smallest patch size that is occupied by spotted owls is approximately 37 acres and the largest patch size is approximately 300 acres, with a mean occupied patch size of 138 acres and standard deviation of 87.1 acres. Most of this habitat is located in the western portion of the watershed, with only scattered smaller stands in the eastern portion of the watershed.

Based upon the U.S. Fish and Wildlife Service determination for "take"; if within the provincial home range radius of any known spotted owl site (1.5 miles for the Coast Range Province) the amount of suitable habitat is less than 40 percent (or 1,809.6 acres for the Coast Range Province), or the amount of suitable habitat within 0.7 miles of a site center is less than 500 acres, then a take situation is likely for that spotted owl site. Suitable habitat is that which is suitable for nesting, roosting, or foraging. The patch types identified in the watershed that provide structural characteristics essential for nesting are mature and old forest habitats. These 2 types have the highest quality of structural characteristics for spotted owl nesting habitat. This amounts to approximately 5,138 acres (see Table 6-2). Old over young, hardwoods, and mixed conifer-hardwood patch types provide structural characteristics primarily for roosting and foraging. This totals approximately 5,985 acres (Table 6-2). The total amount of habitat that is considered suitable for nesting, roosting, and foraging within the watershed is approximately 11,228 acres. This equates to a maximum of, approximately, 6 spotted owl sites within the watershed, having 40 percent suitable habitat within each sites' provincial radius. This assumes that the habitat is evenly distributed across the entire watershed. Current distribution of foraging and roosting habitat is such that most of this habitat is located in the eastern half of the watershed and most of the nesting habitat is located in the western portion of the watershed (see Map 14, Northern Spotted Owl Habitat). Therefore, at this point, it is highly unlikely that spotted owls will be found nesting in the eastern half of the watershed and will nest primarily in areas with larger more contiguous patches of older forests located in the western portion of the watershed.

Current habitat conditions and the amount of available suitable habitat, indicate that there is a potential for a decrease in the number of spotted owl sites located within the watershed. Surveys conducted in 1994 document occupancy in only 3 of the 10 spotted owls sites in the watershed. Only one of those sites showed successful nesting, where at least one young and was produced. This low number of occupied sites may be the result of a poor year of nesting activity, or may be the effect of a decrease in the amount of suitable habitat over recent years. Plans to manage large areas of forest land for late successional wildlife species have the potential to increase acres of suitable spotted owl habitat in the watershed. This increase may not be realized for another 80 to 100 years and, because of a natural delay, owl numbers may not increase for years after that. The current number of owl sites located in the watershed may misrepresent the carrying capacity of the habitat in the watershed, and several sites may become permanently unoccupied in the future.

Dispersal habitat for spotted owls is habitat that is structurally capable of providing cover and flying space for dispersing owls. There is no official definition for spotted owl dispersal habitat, but forest stands that are old enough to allow unobstructed flight under the canopy are potential dispersal habitat for owls. The patch types within the watershed identified as primary dispersal habitat are pole-young and mature over young. These 2 types have some structural characteristics suitable for foraging, roosting, and nesting habitat. These characteristics are very limited and no nest sites are known to occur within these patch types in the watershed. These roosting, foraging, and nesting types total approximately 12,879 acres (Table 6-2). The total amount of habitat that can be used as dispersal habitat by spotted owls in the Wolf Creek watershed is approximately 24,150 acres. Dispersal habitat functions best for spotted owls in a contiguous, nonfragmented condition. The distribution of habitat suitable for dispersal in the watershed is the less fragmented, eastern portion of the watershed. This habitat consists primarily of younger aged forests. The more fragmented western portion of the watershed consists primarily of older forests with larger expanses of nonsuitable habitat between the older forest patches. This habitat configuration potentially allows "easier" dispersal for spotted owls in the eastern portion of the watershed where there is contiguous dispersal habitat with unfragmented corridors. As the forest stands in the watershed continue to develop, there will be more available nesting habitat in the eastern portion of the watershed sooner than in the western portion of the watershed. This area has the highest potential for colonization by dispersing spotted owls.

<u>Marbled Murrelets</u> - The situation for marbled murrelets is similar to spotted owls. Marbled murrelets require large moss-covered limbs for nesting and these are found primarily on large old growth trees 200 years or older. The highest potential for nesting habitat is located in the western portion of the watershed. Because marbled murrelets do not require other types of forested habitat for their terrestrial life needs, they are limited to the areas where old forests exist. Assuming that murrelets fly directly to the nest site without stops, and use river and stream corridors as flight routes, the only other patch type that may be necessary for marbled murrelets in the watershed are riparian corridors. As younger forests develop, more habitat in the eastern portion of the watershed will become suitable for marbled murrelet nesting than in the western portion.

<u>Roosevelt Elk</u> - Roosevelt elk use all of the habitat types in the watershed for some portion of their life requirement needs; they rely heavily on clear cuts for foraging, younger aged forest stands (pole-young and sapling-pole) as hiding cover, and old and mature forest as optimal cover. Optimal cover is habitat that can supplement many life requirements for elk. It has structural characteristics that provide thermal pockets for thermoregulation. This is most beneficial to elk on very hot summer days when the temperature in these old forests is sometimes 20 degrees lower than in open clear cuts. Additionally, optimal cover provides sources of forage.

The effectiveness of elk habitat within the watershed is discussed in Chapter 5. The effectiveness of cover and forage habitat within the watershed is relatively low and does not contribute adequately to the overall habitat effectiveness. However, this is difficult to manage for because, as you increase the amount of forage habitat within a given area (clear cut), you decrease the amount of cover habitat. The effectiveness of foraging habitat can be increased by grass seeding and fertilizing recently burned clear cuts. This practice is seldom done, unless specifically for elk management. Increasing the effectiveness of cover habitat can be accomplished by increasing the amount of optimal habitat in the watershed. This could be done by allowing younger aged forests to develop multi-storied canopies, large diameter trees, and higher crown closures, and thus developing into old forests.

The most effective method of increasing the overall habitat effectiveness of the habitat in the Wolf Creek watershed is road closures. With 5.6 miles of open road per square mile in the watershed, the impacts to elk are extremely high. Christensen et al.[12] conducted an analysis on Rocky Mountain elk in the Northern Region of the Forest Service. He determined that the probability of elk death during hunting season is between 85 and 100 percent with road densities of 5.0 mi/mi? or greater, increasing with increased hunter density. The thicker understories and brush communities that comprise most of the habitat in western Oregon give the Roosevelt elk higher chances of survival during the hunting seasons. However, high road densities are extremely detrimental to elk in all habitat types.

Other patch types located in the watershed include: rocky patches, ponds and bogs, and altered patches (quarries, agricultural land). These patch types may affect wildlife by providing potential forage and wallowing areas for elk. They can also increase vulnerability to elk by providing places for poaching to occur. Additionally, these areas may be barriers to elk travel, as elk are forced to travel around these patch types.

Corridors - There are 3 identified corridors in the Wolf Creek watershed that may affect terrestrial wildlife: roads, streams, and riparian areas. These corridors can impact wildlife in many ways, some beneficial and some not.

Roads - Roads can be disruptive and barriers to wildlife. They can also be the major reason for the death of wildlife (hunting access, poaching), or they can be travel routes for wildlife. As mentioned above, roads are the largest reason for poor elk habitat effectiveness in the watershed and in each of the Elk Management Areas. Newly constructed roads through elk migration areas can impact the migration patterns, potentially making them more vulnerable to predation and hunting.

The impact to spotted owls by individual roads is minimal. On occasion, radio tagged owls have been located near newly constructed roads, possibly preying upon the small mammals that have been exposed or displaced by the new construction (G. Miller, personal observation). However, as road densities increase, the impact to spotted owls increases. This is mainly due to loss of habitat. It may also be the result of increased activity for predatory birds like red-tailed hawks and great horned owls. These birds fly along road corridors and open areas in search of prey. As spotted owls become more exposed from road densities, they become more vulnerable to predation. New road construction can impact owls during the nesting season by harassing owls that are near active construction sites. This usually is alleviated by seasonal and distance restrictions on road construction.

For marbled murrelets roads have very little, if any, impact. Because of the flight speed and patterns, marbled murrelets spend little time flying over ground. Once settled on the nest, these birds rarely move except to be replaced by the other adult or from local disturbances. Ground disturbing activities, like road construction, can impact marbled murrelet activity during nesting. This can be mitigated by seasonal and distance restrictions.

Streams - Streams can play an important role in providing water and cooling areas for elk. In addition, stream flow and channel morphology can impact elk travel. The larger, deeper, and faster flowing streams can be barriers to elk travel. However, most of the streams in the watershed are small enough for elk to cross. Stream systems may be the primary travel routes for marbled murrelets. As these birds fly in from the ocean, they may use the stream as a "path" to the nest site; however, this is theory and has not yet been proven.

Riparian Areas - Riparian areas potentially play a very important role for terrestrial wildlife. Telemetry studies on spotted owls have shown that owls use the riparian zone as primary travel routes. Owls often avoid flying over a ridge with suitable habitat, opting to fly down a riparian zone to the confluence of a creek, and up another riparian zone.[13] This behavior may be due to the larger trees normally found in the riparian zone, the more open flying space for owls to travel through, the large amounts of down woody material that are essential for the prey items for spotted owls, or **because** it is easier for owls to fly around a ridge than to spend the extra energy flying uphill over the ridge. With the emphasis placed on dispersal areas between Late-Successional Reserves, it is even more important to provide healthy and continuous corridors (buffers) along riparian zones for successful spotted owl dispersal.

Elk use riparian zones as major travel corridors. Additionally, elk and deer travel along the least restrictive pathways. Generally, elk travel to and from bedding and forage areas along creeks. Healthy and continuous riparian corridors will enable elk to travel with less vulnerability to predation, hunting, poaching, and heat.

Habitat Components - An analysis was performed on 2 important habitat components within the Wolf Creek watershed: snags and down wood. This analysis revealed that the amount of snags (11" dbh and greater) present in the watershed are sufficient to meet the Eugene District Resource Management Plan guidelines for cavity nesting birds (woodpeckers). The RMP guidelines call for retaining sufficient levels of snags to support species of cavity nesting birds at 40 percent of potential population levels. These levels are designed to accommodate nesting habitat only, and do not consider foraging or roosting habitat.

Of immediate concern is the lack of snags that are in a soft decay class 15 to 17 inches dbh. These snags meet the essential needs for 2 species of cavity nesting birds, the red-breasted sapsucker and the hairy woodpecker. Because of the difficulty in creating soft snags, which naturally take 10 to 15 years to develop[14], there is no short-term solution to this problem. However, creating snags in the proper size classes now as well as creating enough to accommodate the quick decomposition rate of snags of this size, the problem of having too few snags can potentially be reversed. This will require that snags be created several times over the course of several decades to build up a reserve of snags of this decay class. After this time, with plans to allow younger aged forests to develop into old forests with naturally created snags, the amount of snags throughout the watershed should be sufficient in numbers and adequately dispersed across the landscape to provide for 40 percent or greater cavity nesting bird populations. With the majority of the watershed (62%) comprised of younger aged forests (clear cut, sapling-pole, and pole-young), and only 25 percent of the watershed composed of patch types with sufficient structure to provide larger diameter snags (old forests, mature, old over young, and mature over young), the snags that will be most available in future via natural mortality will be smaller sized snags from forest stands with average live tree diameter of approximately 14.4 inches dbh.[15] This also indicates that it will take a longer time for snags in the larger size classes to become available.

There is an increasing interest in the role of down woody material and how it functions in the ecosystem. Down woody material is essential to many wildlife species, both directly and indirectly. Irwin et al.[16] has shown that spotted owl foraging locations are correlated with relatively high amounts of down woody material. This correlation is assumed to be the result of prey species availability and habitat requirements. The small mammals that spotted owl prey upon use down wood for hiding and travel ways while foraging.

The amount of down wood present in the watershed falls within the lower limits measured for unmanaged forests in western Oregon (see page 6-3). As with snags, the patch types best suitable for providing down woody material of substantial size are old forests and other types with large, old trees. Patch types with younger aged stands have smaller trees that decompose very quickly and do not provide long-lasting benefits for wildlife species. With the increasing demand for wood products, logs that were historically left on the landscape after a harvest, are now being logged and brought to a mill for processing. Currently the highest potential for down wood to occur within the watershed is in the western portion where the largest amount of old forest exists. The areas in the eastern portion of the watershed primarily have younger aged forests with smaller sized trees. These trees take longer to arrive at a state that allows them to become large down wood material on the forest floor.

The District RMP indicates that 240 linear feet of logs that measure at least 20 inches in diameter and 20 feet long, will be retained on the landscape after a harvest. This equates to approximately 7.8 tons per acres. This amount ranges from 3 to 31 percent of the amount of down woody material that naturally exists on the landscape in unmanaged forests.

The potential for higher amounts of down wood to occur on the landscape increases with development of the younger aged forests to old forests. This may not be realized for another 60 to 100 years depending on the health of a forest stand, the development of the stands, and future management practices.

The Social System

The humans, plants, animals, and other physical elements of an ecosystem are connected in an interdependent web. Ecosystems are connected to one another at various scales. Some of these connections are very complex and difficult to detect or even imagine. For example, scientists have observed a thinning of the ozone layer but have not yet developed a full understanding of all the contributing causes.[17] A way to try to understand the social system operating in or affecting the Wolf Creek watershed is to examine the known interactions human beings have with the watershed's major landscape elements and processes. Virtually all human presence and/or activity within the watershed affects the physical and biological elements and processes. Many human activities outside the watershed have effects also (e.g., domestic and international demand for timber resulted in intensive timber harvesting).

Human interactions with landscape elements and processes tend to be linked most often to land uses, particularly in terms of commodity extraction, residency, recreation, and transportation.

The potential for human interaction with any of the landscape elements or processes is determined primarily by access. As a general rule, people will not be present in parts of the landscape where there are no nearby roads or trails and the terrain is very steep or the vegetation is extremely dense, i.e., places where foot or vehicular travel is very difficult. The historical record supports this premise (see Chapter 5). On the other hand, in those parts of the watershed where human access has been created with roads and trails, human presence and activity has a substantial effect on landscape elements and processes.

Matrix - The matrix areas consisting of pole-young stands, clear cuts, riparian areas, and streams demonstrate this relationship. People are largely excluded from the pole-young stands because these stands are very difficult to penetrate and sight distances are severely limited, often to no more than a few feet. People are also not likely to spend much time traversing clear cuts. However, they are often attracted to the roads or trails passing through or beside clear cuts for the hunting, gathering, and wildlife or scenery viewing opportunities clear cuts provide. Streams and riparian areas where there is good access may experience considerable human use for such activities as fishing, swimming, picnicking, or camping.

Patch Types - The patches (old forest, hardwood, ponds, etc.) include the full range of forest types and nonforest land uses. Human interactions that affect patch elements and processes are primarily associated with extractive or consumptive activities. Commercial timber and mushroom collecting activities are most likely to occur in the old forest and mature patch types. These patch types are also valued for their aesthetic and spiritual experience opportunities and for their study or research potential. Old over young and mature over young patches have some commercial value for timber and limited recreational value, primarily for hunting, because access and visibility can be impeded for dense understory vegetation. Sapling-pole patches are of little interest either commercially or for recreational uses. They act as screen, generally excluding human use or interaction and blocking viewing opportunities. Mixed conifer-hardwood and hardwood patches provide visual interest and contrast to the landscape that enhances aesthetic appreciation opportunities, especially during the fall leaf-turn. These patches are also valued for hunting and gathering activities and may provide sources for fuelwood, burls, and nuts. Rocky patches attract human interest for botanical study and the visual contrasts they provide for landscape viewing. Some rocky patches may also be used for quarry sites. Ponds and bogs provide visually interesting contrasts to the landscape and may attract people for their aesthetic value. They are generally barriers to human travel. When associated with altered patches such as farms or ranches, ponds and bogs are often heavily used by people as watering sources for domestic animals. Altered patches include such things as farms, home sites, and rock quarries. Because these areas were modified or improved in order to satisfy a specific human need, they are sites of intensive human use and occupation, and natural processes have been deliberately displaced. Altered patches are generally barriers to natural flows and interactions within the watershed and can be sources of pollution and exotic species introduction.

Corridors - Roads are the primary corridors for human access and travel within and through the watershed. In this watershed the proliferation of roads means that human interaction with the natural components of the watershed is concentrated on and immediately adjacent to the roads.

Mass Wasting - Mass wasting has the potential to reduce or exclude human interaction with parts of the watershed by limiting access. Such access limitations are usually temporary and repair work to roads or bridges may result in increased human presence and interaction with the landscape at mass wasting sites.

Channel Morphology - Channel morphology defines most of the water based recreational opportunities. In this watershed activities such as wading and crawfish collecting are enhanced by the numerous stretches of broad, relatively level exposed bedrock stream channel along Wolf Creek. Pools along Wolf Creek are attractive for fishing and swimming. Most of the watershed's smaller stream channels are not interesting for recreational purposes. Wolf Creek Falls attracts recreational use due to its aesthetic qualities and wildlife viewing potential that is directly associated with channel morphology.

Flows - Water flows have a substantial effect on the potential and realized human interactions occurring within the watershed. The quantity and duration of flows determines what beneficial uses of water are possible and which water rights can be enjoyed by their owners. Low flows preclude human uses such as boating and fishing, while high flows may exclude virtually all recreational or other human uses because of hazardous conditions and loss of access due to flooding. High flows may reduce property values by making flood zones unsuitable for most types of development. Engineering requirement and costs for building bridges are also determined by peak flow expectations. The flow regime can be a major limiting factor on the watershed's value to the commercial fishing industry as a spawning and rearing habitat for anadromous fish stocks.

Sediment - Sediment in sufficient quantities will limit human use of the watershed's streams for domestic and recreational water uses. High sediment loads can result in streams being unsuitable as drinking water sources or can substantially increase the costs for filtration and treatment for domestic water users. Sediment loads increase turbidity and reduce the aesthetic qualities of streams, which in turn limits the stream's attractiveness for recreational uses. If sufficiently high and prolonged sediment loads occur, fish populations can be damaged or destroyed, limiting the watershed's value as a base for the commercial and sport fishery.

Stream Temperature - Excessively high stream temperatures can destroy valuable fish populations and render the stream unsuitable for valuable cold water species, thereby limiting commercial and sport fishing opportunities within and downstream of the watershed. Extremely cold stream temperatures can limit the attractiveness of the stream for water-contact activities such as swimming or wading.

Soil Productivity - The potential for growing plants is affected by the watershed's soil productivity. Timber and agricultural crop productivity are directly dependent on soil productivity.

Summary

The interaction between wildlife and the habitat, and wildlife and other wildlife, that exists on a landscape is very important to a proper functioning ecosystem. Each wildlife species fills a niche within an ecosystem and each habitat type assists in the fulfillment of that niche. To ensure that biological diversity is represented within any given watershed or sub-basin, it is important to consider all habitat types that may have been and are present. These habitat types should be in adequate proportions to provide proper function of all components included within a larger ecosystem. In turn the watershed as a whole should function properly to provide for adjacent watersheds and not become an area that limits the health of a river basin or geographical province. Currently, the biodiversity status, or status of diversity of all living organisms, of the Wolf Creek watershed is not completely known and efforts should be taken to determine such.

The major concerns that accompany the watershed and its contribution to the Siuslaw Basin are water temperature, road density, and old growth habitat. Water temperature can impact a large portion of the Siuslaw Basin by continuing to elevate already high temperatures. High temperatures in the Siuslaw River may be more difficult to mitigate but, by decreasing the temperatures in watersheds that flow into the Siuslaw, a large step can be taken. Road density can be decreased with an aggressive travel management plan incorporating cooperation from private landowners and the public. This may take several steps and levels from gating roads, to rehabilitating roads, to developing a "green dot/red dot" road closure honor system during hunting seasons. The lack of and fragmentation of old growth forests within the watershed is a by-product of previous forest management activities. Changing public sentiment about national forests and other public land, and subsequent changes in forest management policy and plans, old growth habitat is now considered more of a valuable resource for its intrinsic values. The plan to establish Late-Successional Reserves for associated wildlife species and managing those areas on the premise of providing habitat for those species, is a testimony for the changing attitude towards the role that old growth forest plays in the large scheme. However, caution should be used in managing for only one wildlife species or one wildlife species guild.

As more and more is determined about the Wolf Creek watershed and the surrounding watersheds, the role that Wolf Creek plays in the function of the Siuslaw Basin or Coast Range Province will become clearer. Management activities designed to enhance the beneficial roles of the watershed should support the proper function of neighboring watersheds and the biodiversity within the Wolf Creek watershed and surrounding landscape. The current landscape pattern in the Wolf Creek watershed is fragmented and unstable. Because the majority of the patch types within the basin are young seral stages, the dynamics associated with succession will change the character and structures associated with this landscape pattern more quickly than older patch types. This faster rate of change can provide some management opportunities in the sense that landscape features and patch characteristics associated with tree size can be easily influenced and some characteristics created more quickly than the pace established by succession. In other cases, some habitat or patch types have been reduced to such low levels that protection is the only management option available in the near term. The landscape and species dynamics will change in the future. Monitoring will be critical to detecting these changes and creating an adaptive management system for the watershed.

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